GEOLOGICAL MAPPING OF QUADRANGLES V-3, V-7 AND V-57, VENUS: PRLIMINARY RESULTS. M. A. Ivanov,1,2 and J. W. Head,1, Vernadsky Inst., RAS, Moscow, Russia, mishaivn@mtu-net.ru, Brown University, Providence, Rhode Island, USA, james_head@brown.edu.

Introduction: Here we present the preliminary results of geological mapping in three quadrangles (V-3, V-7, V-57) mapped under the USGS Program of geological mapping of Venus. These quadrangles significantly extend the area of four quadrangles (V-4, -13, -55, and -61) where we accomplished geological mapping [1,2] and cover different topographic provinces and characterize a wide variety of geological situation. Thus, they represent additional test areas for both the applicability of mapping techniques and models of regional to global stratigraphy and proposed models of the geologic history of Venus [3-5].

Main geological themes of the quadrangles: 1) Meskhen Tesser a quadrangle (V3, 50-75N, 60-120E): This area represents the transition from the large lowland to the east (the Atalanta Planitia basin) and the highlands to the west (Ishtar Terra, Fortuna Tessera). Three large occurrences of tessera characterize the map area: Fortuna Tessera to NW in the eastern portion of Ishtar Terra, Dekla Tesserae in the SW corner of the quadrangle form a large tessera arc, and Meskhen Tesser a in the NE corner of the map area dominates the western portion of Thetus Regio. Tessera terrain in these areas is the oldest material unit and occurs at prominent topographic highs that are several hundreds of meters up to a few kilometers higher than surrounding territories. Large deformational belts of grooves and ridges occur predominantly within the elongated lowland of Audra Planitia (about 1000 km long and 500-600 km wide) between Fortuna and Dekla Tesserae. The ridge belts are usually in contact with the arc of Dekla Tesserae and the groove belts occur in the middle of Audra Planitia near the southern edge of Fortuna Tessera. Fragments of the deformational belts there are roughly parallel to the strike of the Dekla arc. Another large occurrence of groove belts is in the central-southern portion of the quadrangle where the belts are almost orthogonal to the orientation of the Dekla arc. The relationships among tessera, ridge belts, and groove belts are consistent throughout the map area. The plains deformed into ridge belts embay tessera massifs and are cut by structures of groove belts. Extensive occurrences of shield plains dominate the regional slopes away from the uplands of Ishtar Terra, Dekla Tesserae, and Thetus Regio. The plains embay older units exposed in the central portions of the uplands and, in turn, are embayed by regional plains within the lower areas. Regional plains deformed by networks of wrinkle ridges make up the most widespread unit and occupy the mid-level of the regional stratigraphic column.

The younger volcanic plains (lobate plains) are not very abundant and occur within the quadrangle in a broad topographic trough between Ishtar Terra and Thetus Regio in association with coronae Ops and Tusholi. Fakahotu Corona is the other area where lobate plains occur. At Fakahotu Corona there is also evidence for tectonics predating regional plains and volcanic flows superposing on regional plains. Fakahotu Corona is at the westernmost continuation of a chain of coronae interconnected by belts of fractures and graben. Vast aprons of younger lava flows surround coronae from this chain (Nightingale and Earhart Coronae within the V-4 quadrangle).

2) The Lakshmi Planum quadrangle (V-7, 50-75N, 300-360E): A large (~2000 km across), high (2-3 km above the surroundings), and roughly circular complex of Lakshmi Planum occupies the northern half of the quadrangle. High mountain ranges encircle the interior of Lakshmi and divide the map area into three large topographic and geologic provinces: A) exterior of Lakshmi, B) the bordering mountain ranges, and C) interior of Lakshmi.

A) Exterior of Lakshmi: A broad zone of heavily deformed terrain surrounds Lakshmi from the south, west, and northwest. The zone represents a complex of tessera massifs, fragments of densely lineated plains, and branches of groove belts in association with small patches of shield plains. Vast regional plains deformed by wrinkle ridges embay all these material and structural units and make up the surface of extensive lowlands to the south of Lakshmi.

Muta Mons in the southeastern corner of the quadrangle is a large source of extensive lava flows that flow downward along the regional slope toward Sedna Planitia. There, the flows are merge and form extensive occurrences of lobate plains. Lobate plains are mostly tectonically undeformed, embay units and structures of the transition zone, and are superposed on regional plains within Sedna Planitia, thus indicating relatively young volcanic activity. At the western edge of the map area, large Omosi-Mama Corona appears to be another source of extensive young lobate plains.

B) Bordering mountain ranges: The chain of mountain ranges that almost completely outlines the interior of the plateau consists of four segments. The lowest segment is at the southern edge of the plateau (Danu Montes, 1.5-2 km higher than the surface of Lakshmi). Akna and Freyja Montes to the west and north of Lakshmi, respectively, are significantly higher (3-3.5 km higher). The highest ranges of Maxwell Montes (5-10 km higher) border the eastern edge of Lakshmi. The mountain ranges of Danu, Akna, and Freyja Montes consist of tightly packed ridges 5 to 10 km wide that morphologically resemble structures of ridge belts [6]. Horst-and-graben-like structures are more common within Maxwell Montes. Where the mountain ranges are in contact with the plains that make up the interior of Lakshmi, there is the evidence for embayment of the ranges by the plains. Along Akna and Freyja Montes, however, the interior plains are sometimes tilted toward the plateau center and appear to be slightly ridged conformal to the strike of the mountain ranges.

C) Interior of Lakshmi: Relatively small and heavily embayed outliers of complexly deformed materials morphologically similar to either tessera or groove belts occur in the interior of Lakshmi. Plains deformed by a network of wrinkle ridges make up the most widespread material unit within the interior. By morphology, albedo, and apparent stratigraphic position, these plains
are most similar to the regional plains elsewhere on Venus [7,8]. The younger plains are characterized by numerous brighter and darker flow-like features or have uniform and relatively low radar albedo. These plains are superposed on the plains with wrinkle ridges, bear almost no tectonic deformation, and are spatially associated with two major volcanic centers, Colette and Sacajawea Paterae. Thus, these plains are analogous to the youngest lava plains on Venus (smooth and lobate plains) surrounding distinct volcanic centers [1,9-11].

Although all types of interior plains show distinct similarities to specific varieties of plains outside Lakshmi, they are completely confined within the Planum and have been mapped as separate units. 3) The Fredegonde quadrangle (V-57, 50-75S, 60-120E): This quadrangle samples the transition from the uplands (Lada Terra to the west) to lowlands (Aino Planitia to northeast). The eastern portion of Lada Terra within the map area lacks occurrences of tessera and the oldest units exposed there are densely lineated plains and ridge belts. Small and heavily embayed fragments of these units corresponding to distinct topographic ridges occur in the central (from the north to the south) portions of the quadrangle.

Several large coronae interconnected by swarms of grooves (groove belts) are the most important features in the quadrangle. The coronae and groove belts form major corona-groove chains corresponding to prominent ridge-and-trough topographic complexes and extending for several thousands of kilometers in the NE direction toward the lowland of Aino Planitia. In many aspects the corona-groove chains within the map area resemble zones at the margins of large basins such as Lavinia (V55) and Atalanta (V4) Planitiae, near which the corona/groove zones run roughly parallel to the edges of the basins. Within the eastern portion of Lada Terra, however, the deformational belts are oriented at high angles to the general strike of Aino Planitia.

Regional plains deformed by wrinkle ridges embay individual structures of the groove belts and large areas of shield plains and occur in the middle part of the regional stratigraphic column. The Regional plains form the most extensive material unit within the map area, and cover the majority of the surface of the quadrangle within both the upland of Lada Terra and the lowland of Aino Planitia.

The coronae from the corona-groove zones are distinct sources of relatively young volcanic materials superposed on the surface of regional plains. Vast lava flows that form the upper unit of regional plains (pwrt) and lobate plains are closely associated with Dunne-Musun and Ambar-on Coronae that occupy a broad topographic high in the center of the quadrangle. Another locus of young volcanism is at Xaratanga Chasma and several large coronae in the NW corner of the quadrangle.

Summary: Despite the different locations and regional geological settings of the three mapped areas, they and the previously mapped areas (V-4, -13, -55, and -61) have distinctly similar set of material units and tectonic structures. The most complete stratigraphic column characterizes the Lakshmi Planum quadrangle (V-7) and consists of 13 units (from older to younger): Tessera terrain (t), Densely lineated plains (pdl), Ridged and grooved plains (prg), Mountain belts (mb, Lakshmi), Shield plains (psh), Regional plains (two units, pwrt and pwr2, characterize the Lakshmi exterior and two units, lpwr1 and lpwr2, occur in the interior of the Planum), Smooth plains (ps), Interior smooth plains (ips, Lakshmi), Lobate plains (pl), and Interior lobate plains (pl, Lakshmi). Five of these units characterize specific features within the Planum interior and may be correlative with their counterpart outside Lakshmi. The same set of units (except for the specific Lakshmi interior units) characterizes the surface within the Fredegonde (V-57) and in the Meskhent Tessera (V-3) quadrangles. Within V-3, however, the upper unit of regional plains (pwrt2) and smooth plains (ps) appears to be missing. The stratigraphic order of the units within all three new quadrangles is the same and appears to be similar to the stratigraphic column found for four previously mapped areas.

The similar sequences of volcanic and tectonic events appear to characterize seven quadrangles mapped so far (V-3, -4, -7, -13, -55, -57, and -61). These areas comprise about 11% of the surface of Venus and form large contiguous zones in the northern and southern hemispheres of the planet. The similarity of the documented events within widely distributed quadrangles appears to contradict the predictions and consequences of the nondirectional model of the geologic history of Venus [5]. On the other hand, such a similarity supports the alternative directional model of the history of Venus [3,4].